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ADF Aircraft Propulsion Systems - Challenges & Lessons Learnt

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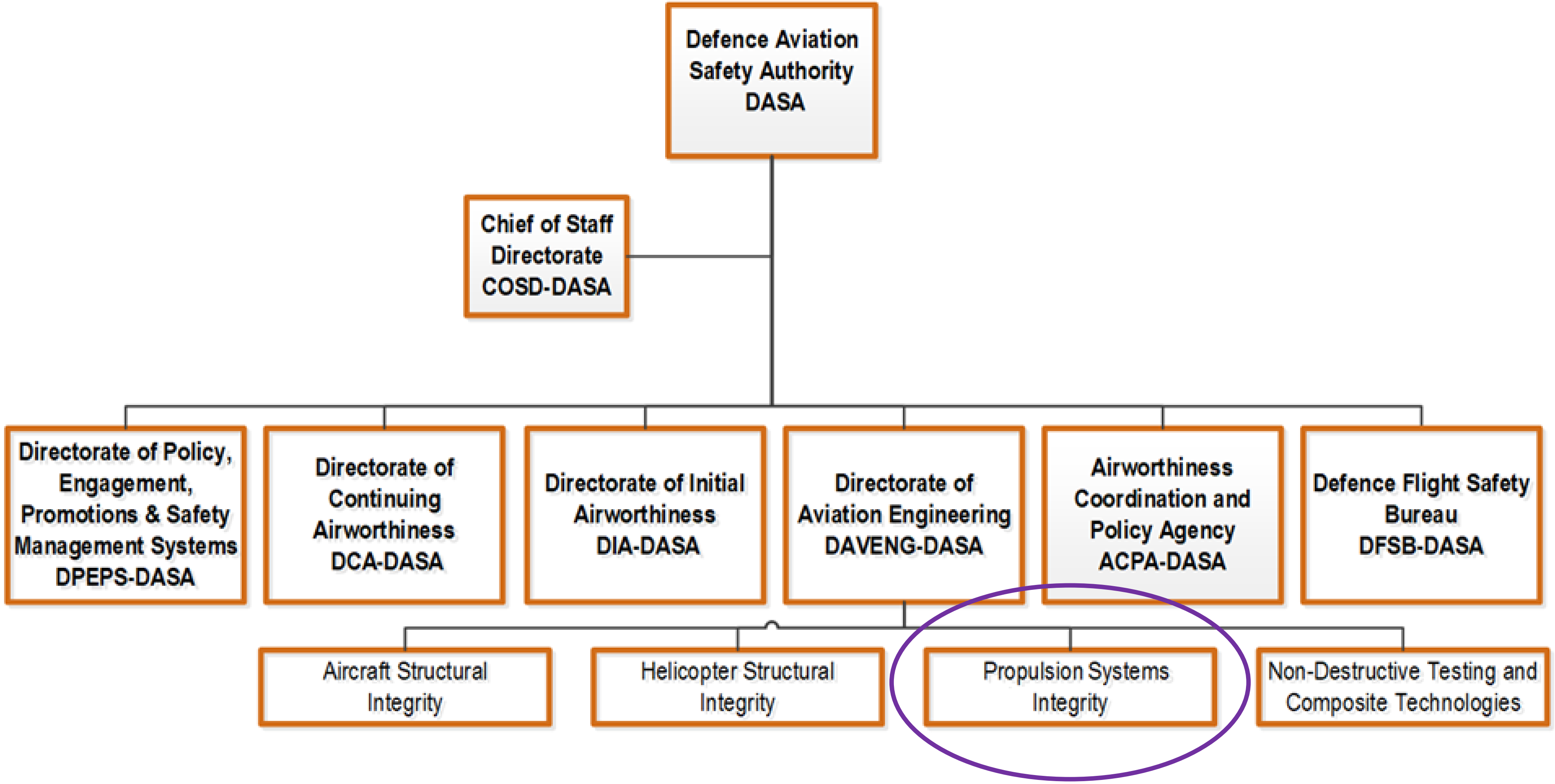
Disclaimer

- Presentation is **my opinion,** based on **my** own experience of being heavily involved in ADF propulsion system management
- You may already know all the information presented here
  - Think if you are actually applying them on a day to day basis
  - Think about how it relates to you & your workplace
- Open to answering hard questions, or to be told you think I'm wrong

PSI in DAVENG-DASA



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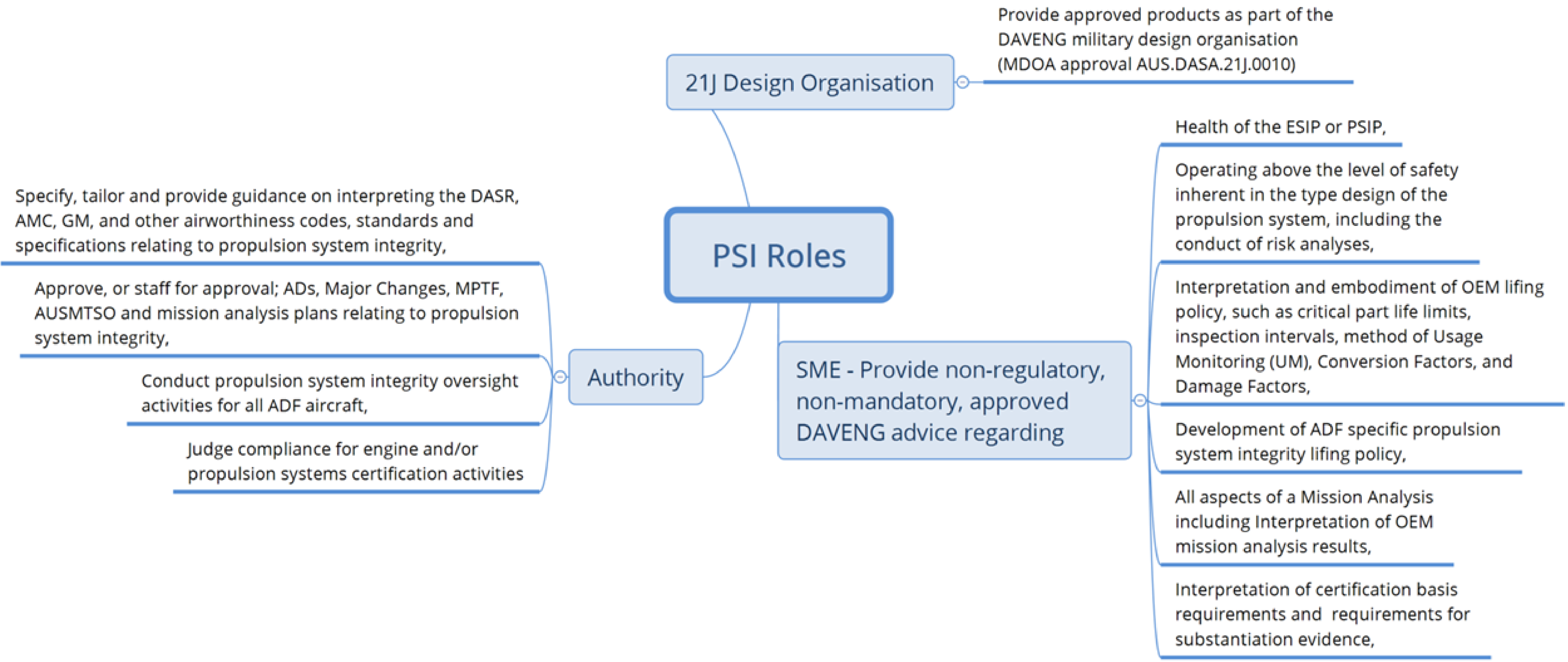

Overview

- Highlight a few recurring issues in the form a case studies
  - Platform reliability lifecycle curve gives a false sense of security to the operators during the mid-life of the platform.
  - Engine health monitoring is vital throughout it’s life
  - Changes to mission mix and missions over the course of the platforms life has deviated from OEM assumptions. Can invalidate OEM life limits.
- Wear Debris Analysis (WDA) overview

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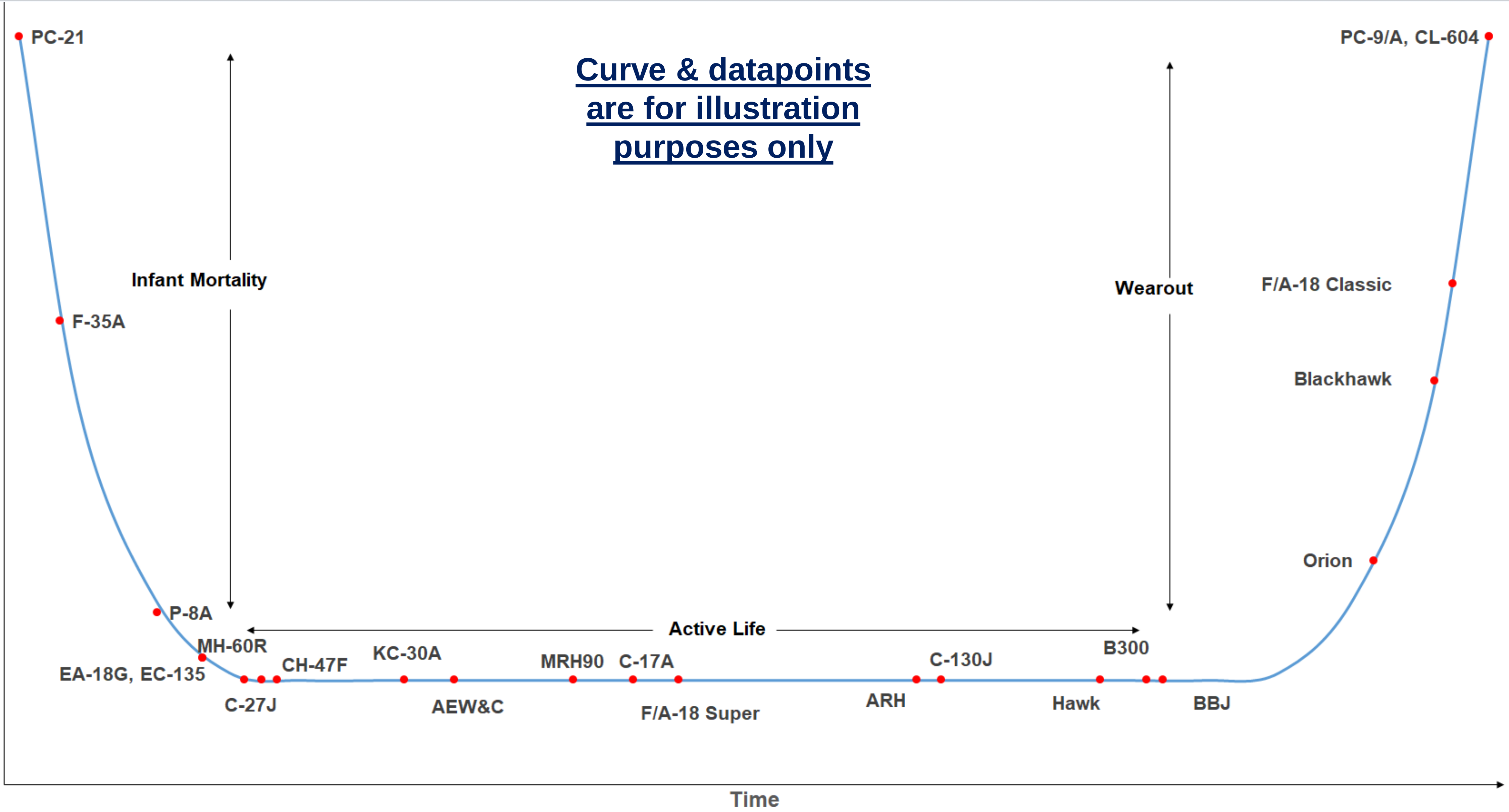
Scrub a dub-dub



Case Study 1 – C130J Engine Degradation

- Presented at the 2018 AA&S conference by StandardAero
- Multiple engine IFSDs in a short period of time
- Cause:
  - Worn compressors
  - Lack of MGT margin
  - Engine attempts to increase fuel flow – attempts to run hot section hotter
  - Significant degradation of hot section – Requires replacement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Case Study 1 – C130J Engine Degradation

- Impact of engine degradation
  - Lack of engine availability – impact on missions
  - Increased engine induction to DM venue
  - Increased cost of engine repair & OH
    - Significant damage on downstream components
  - Increased maintenance burden
    - Engine removal & installation
    - Increased effort to make other aircraft serviceable

Case Study 1 – C130J Engine Degradation

- Rectification
  - Resurgence in active engine health monitoring
    - Used to be conducted in anger a few years prior to failures
  - Fleet planning to schedule engine removals
  - Preventative maintenance to maintain engine health
  - Introduction of OEM limits to the compressor, which is seeing all compressor blades replaced at next shop visit.
  - 5 year compressor remediation program to have all engines return to the shop to have their compressors replaced.

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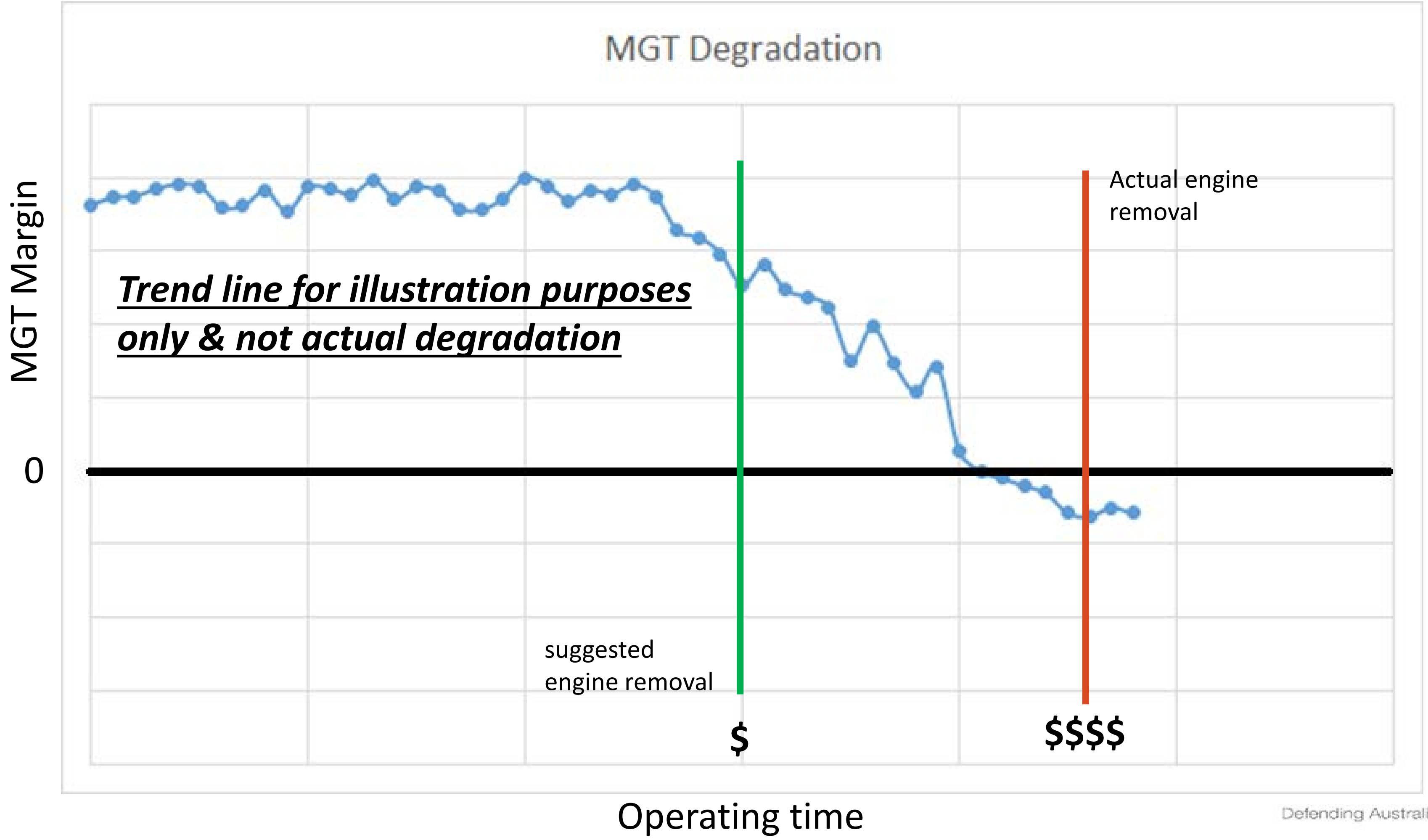
Case Study 1 – C130J Engine Degradation



Case Study 1 – C130J Engine Degradation

- Key takeaways
  - Complacency when engine fleet is serviceable
    - Dropped the ball in engine health monitoring
    - Reduced emphasis on proactive engine inductions
    - Reduced emphasis on preventative engine maintenance
  - Lack of understanding of importance of continued effort in engine health monitoring
  - High reliability gave CAMO a false sense of security
  - Posting cycle impacted on engine health management
  - Having a health monitoring system is useless if no one is actually doing anything with the information

Case Study 2 – ADF Helicopter Engine

- Recently an ADF helicopter suffered an engine component failure
- Investigation revealed:
  - A PT blade migrated forward within its PT1 disc slot
  - Blade liberation caused secondary damage to PT1 and PT2 blades, cascading with further liberation of debris
  - First of type in global fleet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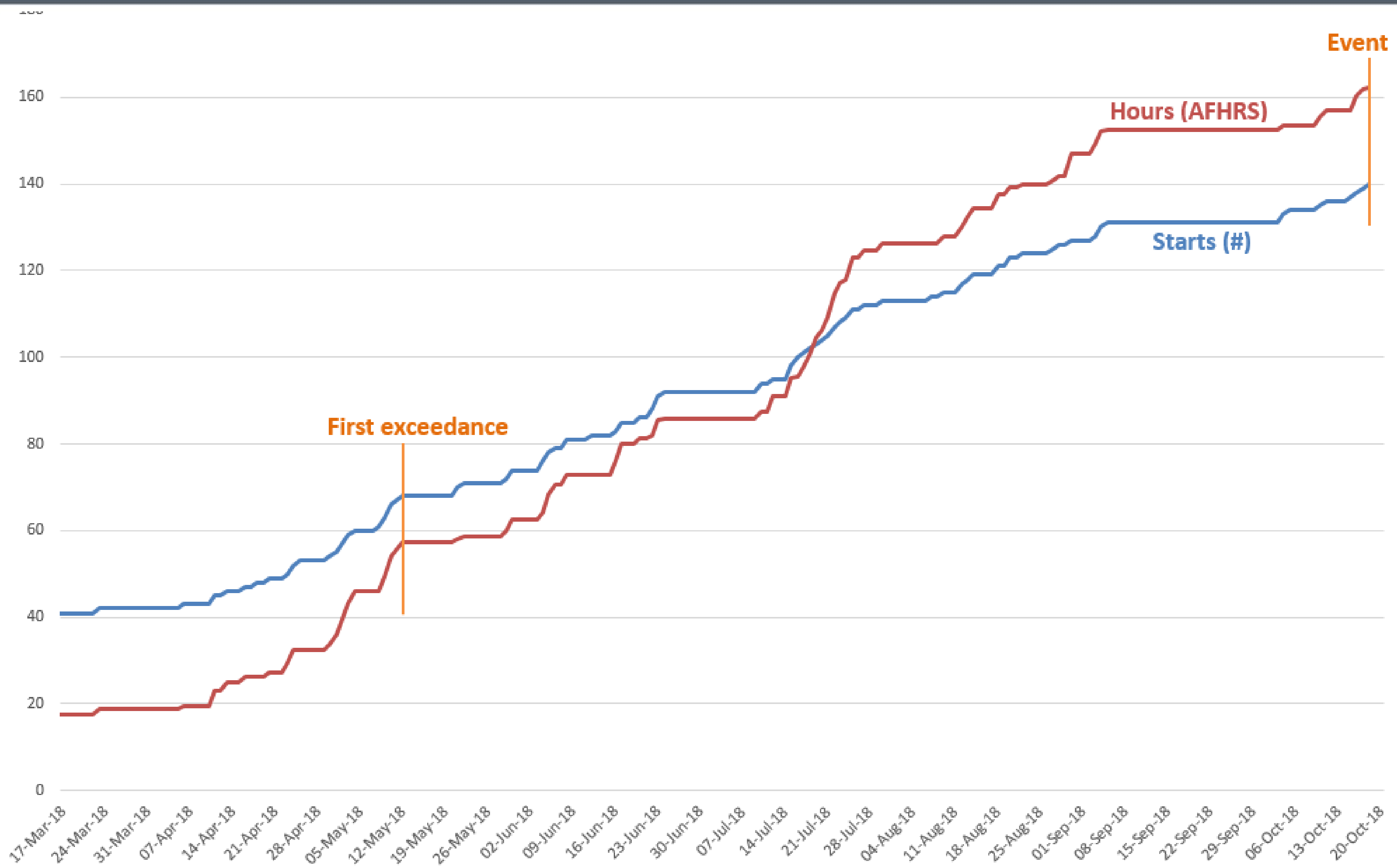
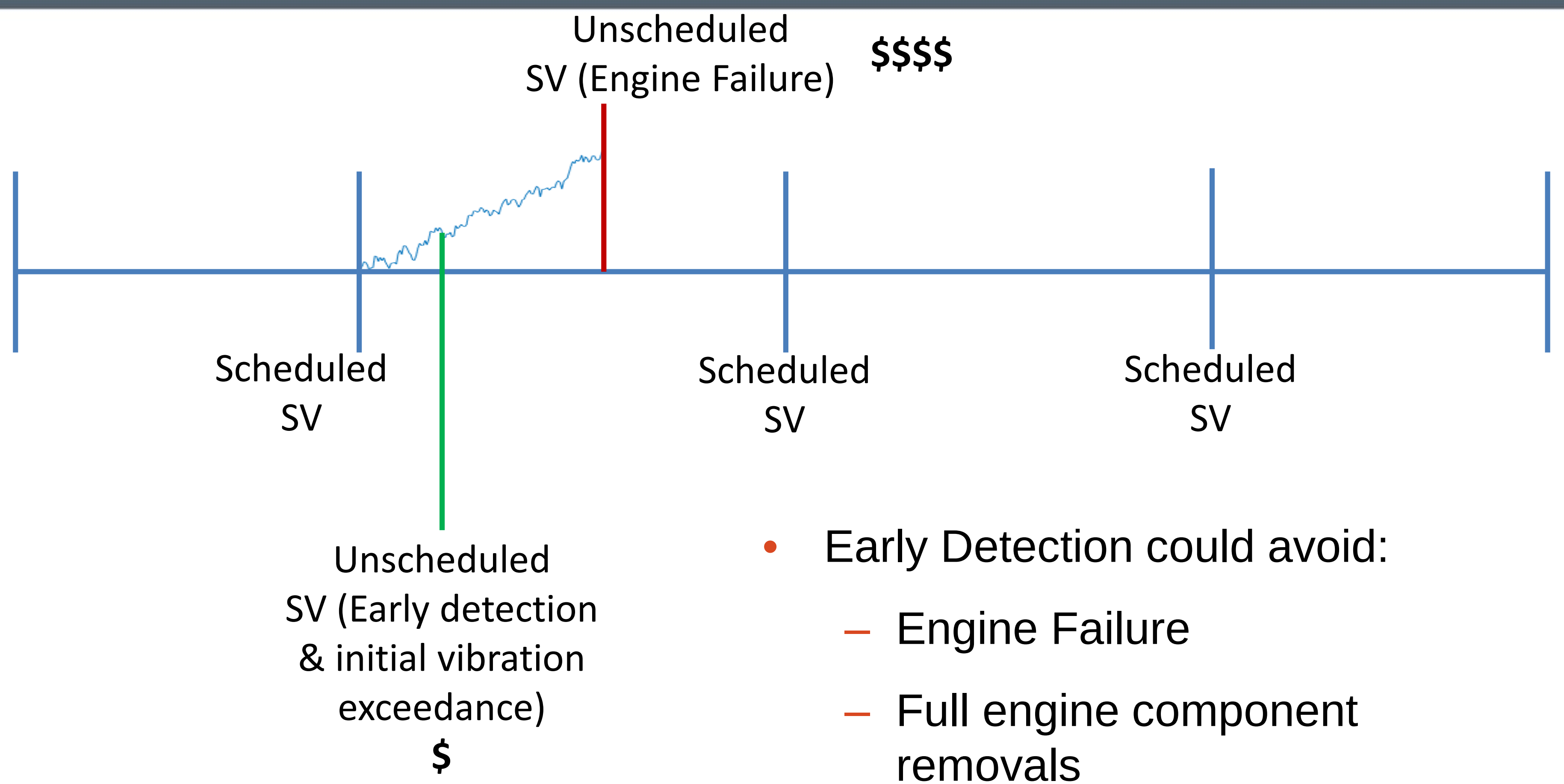
Case Study 2 – ADF Helicopter Engine



Case Study 2 – ADF Helicopter Engine



- Early Detection could avoid:
  - Engine Failure
  - Full engine component removals
  - Potential pause in operations

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Case Study 2 – ADF Helicopter Engine

- Engine health monitoring systems are useful
- Can potentially capture impending failures
- Cost of verifying health monitoring system is almost certainly cheaper than an engine failure

Source: Bill Chambers - http://www.3squadron.org.au/subpages/MirageFun.htm

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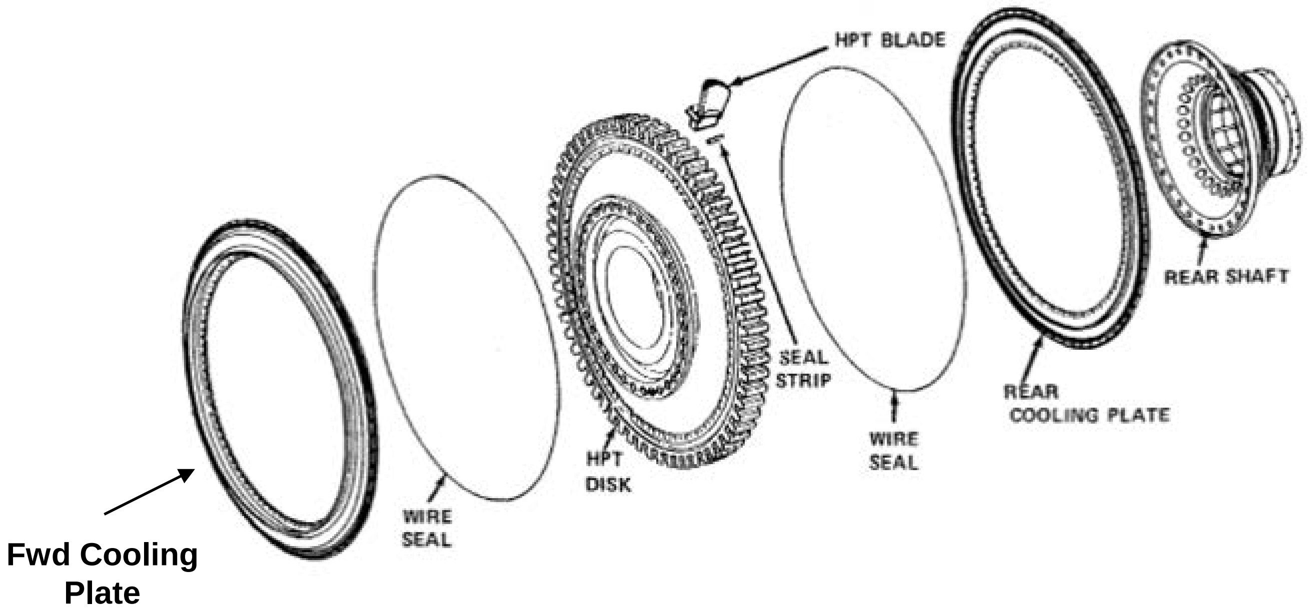
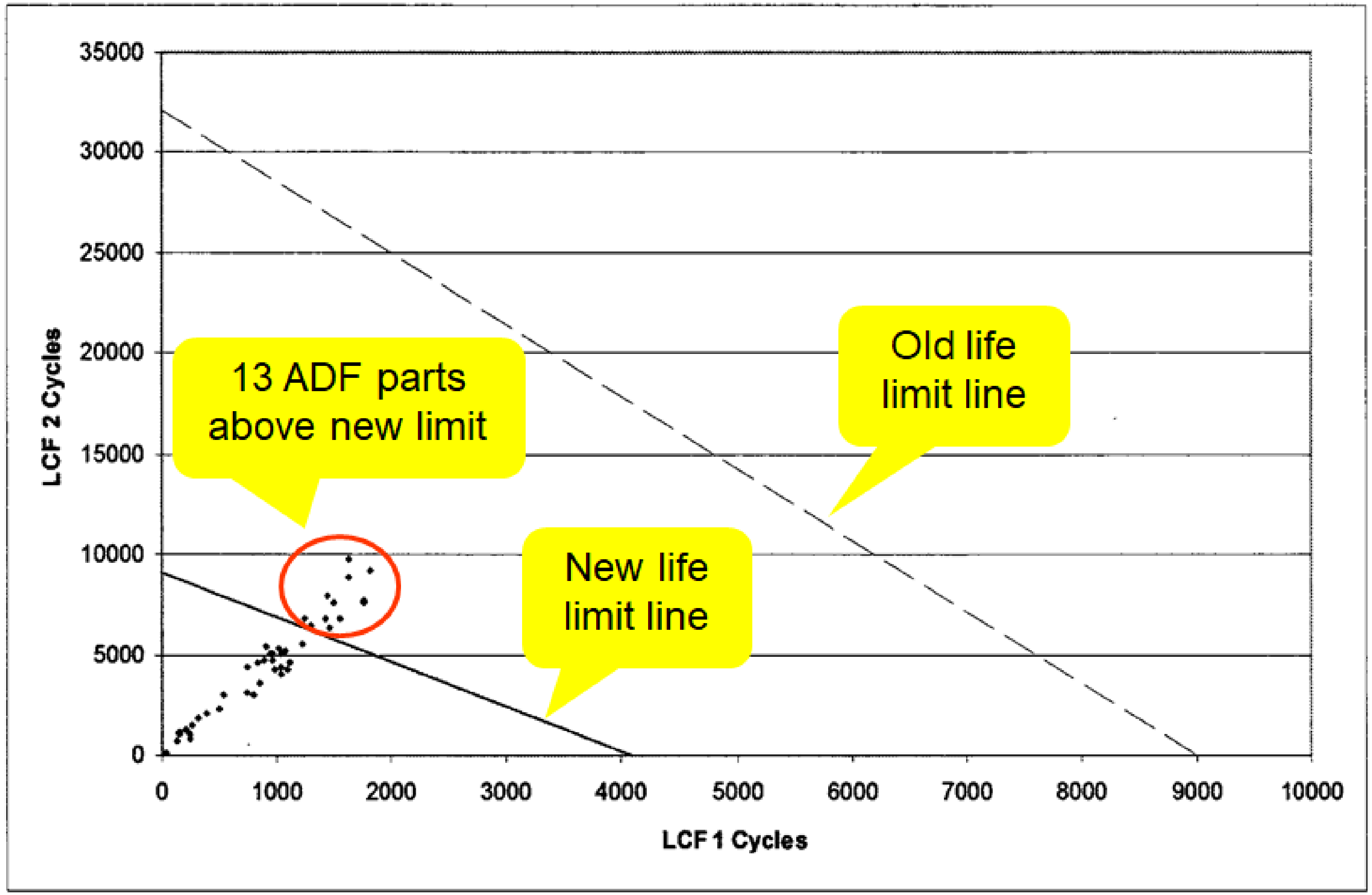
Case Study 3 – Classic Hornet Life Reduction



Case Study 3 – Classic Hornet Life Reduction

- OEM advised that an engine's life limits had been reviewed (using updated methods) and life limits would be updated
  - The 1st Stage Forward Cooling Plate (1SFCP) suffered a substantial decrease
  - No in-service 1SFCP failures
  - 13 ADF engines had 1SFCPs over the new limit
  - 7 of those were able to be removed and retired, but SPO sought DASA (then DGTA) approval to fly the remaining six 'overflown' engines for a further 500 ENHRS each
    - Post significant engineering effort – Approval given

Case Study 3 – Classic Hornet Life Reduction



Case Study 3 – Classic Hornet Life Reduction

- **Issue:** Unexpected decrease in critical component lifing
- **Effect:** Multiple aircraft could have been made immediately unserviceable
- **Cause:** Review of ADF usage was not conducted for approximately 8+ years
  - Changes to mission profiles
  - Improvements in OEM critical component lifing models
- **Lesson Learnt**
  - ADF Configuration, **Role** & Environment (CRE) consistently change – Will have an impact on critical component lifing
  - Review ADF Usage against OEM design assumptions every 3-5 years
  - A good understanding of the relevant lifing philosophy and process is required, including great relationships with the OEM

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Case Study 4 – Engine Preservation

- **Situation:** During a compressor wash, gravel/ceramic substance was discovered in the turbine case drain hole
  - Substance was identified as Magnesium Oxide
  - Further investigation reviled **significant** corrosion of the reduction gearbox
  - Corrosion penetrated the case
- Engine in question: 16 months inactive in the previous 3 years of service
- **Cause:**
  - Age
  - ***Lack of preservation during inactive time***
  - Multiple maintenance venues & organisations

Case Study 4 – Engine Preservation

Case Study 4 – Engine Preservation

- **Effect:**
  - Fleet inspection of RGB for corrosion
  - Permanent change to publications to conduct boroscope inspections to identify corrosion
  - Conduct further analysis of water captured from compressor washes to detect MgO
  - Another costly fleet recovery activity

Case Study 4 – Engine Preservation

- **Lessons Learnt**
  - Corrosion is a known issue - correct engine preservation policy could have reduced impact
  - Maintenance system doesn't always interact well with the logistics system
  - Not the only platform impacted by an inadequate maintenance & logistics interface
  - Must have oversight of all aspects of the engine from manufacture through to disposal

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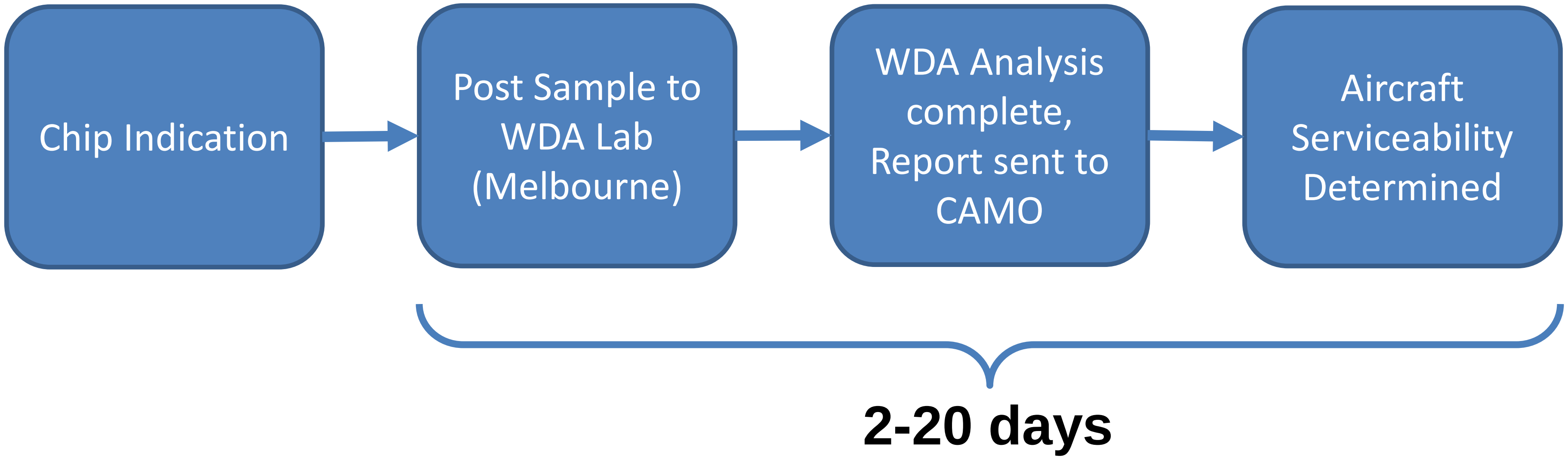
ADF Wear Debris Analysis - Improvements

Current Approach



ChipCHECK

- The ChipCHECK instrument is specifically designed for in-field composition analysis of aviation propulsion machinery wear debris

Image courtesy of GasTOPs

- Manufactured by GasTOPs Ltd and is commercial off-the-shelf
- Uses Laser Induced Breakdown Spectroscopy (LIBS) to determine elemental composition of wear debris

ADF Wear Debris Analysis - Improvements

- ChipCHECK – Operation
  - Debris are collected, washed and placed on an adhesive patch then into a sample tray. The sample tray is loaded into the instrument.

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ChipCHECK Patch Analysis Summary Report

SAMPLE IDENTIFICATION

Sample Source

Aircraft	DST Test
Designation	AXX
Aircraft Tail Number	X1
System	Propulsion AXX
Location of Collection Device	1 Test Eng Filter
Serial Number	Brass 1
Not Required	
Sample ID	1827198400135
Not Required	

Sample Analysis Result

Equipment Condition Status — To Be Developed

Analysis/Analyzer

Not Required	MCD 1
Unit Serial Number	271984
Date of Analysis	2018-06-25
Date Run	2018-06-25 12:22:06 PM
Reason for Analysis	Other
Analysis Completed By	pcs
Notes	test cust

PATCH ANALYSIS SUMMARY

Patch Analysis Results

Alloy	No. Particles	Particle Area (um2)		
		Min	Max	Total
Brass	13	9,010	713,684	4,538,620

Patch Image (2592 x 1944)

(-1296,-972)------(1296,-972)

(-1296,972)------(1296,972)

PARTICLE ANALYSIS SUMMARY

Particle ID	Area Size (um2)	Centroid XY	Alloy Match
1	713,684	{X=586,Y=260}	Brass
2	672,995	{X=175,Y=-323}	Brass
3	502,741	{X=-99,Y=275}	Brass
4	445,137	{X=251,Y=403}	Brass
5	404,971	{X=-461,Y=402}	Brass
6	402,414	{X=-263,Y=-419}	Brass
7	374,222	{X=531,Y=-219}	Brass
8	347,484	{X=491,Y=-585}	Brass
9	340,857	{X=-575,Y=-196}	Brass
10	295,053	{X=-507,Y=-572}	Brass
11	16,915	{X=-183,Y=-338}	Brass
12	13,137	{X=-374,Y=39}	Brass

ChipCHECK ONLY BY GASTOPS

gastops LONG LIVE EQUIPMENT

Intro
Overview
Bathtub
Case Study 1
Case Study 2
Case Study 3
Case Study 4
Wear Debris
Lessons Learnt

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ADF Wear Debris Analysis - Improvements

Chip Indication → Analyse Sample in ChipCHECK (insitu) → Aircraft Serviceability Determined

Few hours

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Lessons Learnt

- Platform reliability lifecycle curve gives a false sense of security to the operators during the mid-life of the platform.
- Engine health monitoring is vital throughout its life
  - Not only when availability is reduced (too late by then…)
- Changes to mission mix and missions over the course of the platforms life has deviated from OEM assumptions. Can invalidate OEM life limits.
- On Extreme situations – Can cause critical component failures

What can happen if a critical component fails

Lessons Learnt

- Platform reliability lifecycle curve gives a false sense of security to the operators during the mid-life of the platform.
- Engine health monitoring is vital throughout its life
  - Not only when availability is reduced (too late by then…)
- Changes to mission mix and missions over the course of the platforms life has deviated from OEM assumptions. Can invalidate OEM life limits. Impacts Critical Components
- **Retention of Lessons**
  - Document within the platform Propulsion System Integrity Management Plan (PSIMP)
  - Corporate knowledge within DAVENG
    - Has access to a repository of historical ADF platform issues
    - Can read across all ADF platforms

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Questions?

Cartoon: Courtesy Lockheed Aircraft Corporation.